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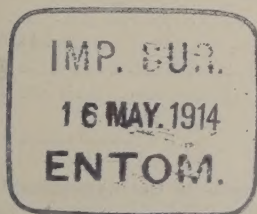
Agricultural Experiment Station

OF THE

College of Agriculture and Mechanic Arts

RALEIGH

The Formation of Nitrates in the Soil.



N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE
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Visitors will be welcome at all times and will be given every opportunity to inspect the work of the Station. Bulletins and reports are mailed free to all residents of the State upon application.

Address all communications to

THE AGRICULTURAL EXPERIMENT STATION,
RALEIGH, N. C.

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The Formation of Nitrates in the Soil

W. A. WITHERS, CHEMIST.

Of the different elements which are necessary for plant growth, nitrogen is the most costly. It is also the element which is most easily lost from the soil.

The value of any fertilizing element depends upon its availability to the plant; that is the readiness with which it can be absorbed directly by the plant or be converted into forms which can be assimilated. Nitrogen is usually supplied to plants for fertilizing purposes in five forms, viz: (1) Free nitrogen gas, (2) certain organic compounds, (3) ammonium salts, (4) calcium cyanamide, (5) nitrates. Free nitrogen is a gas and makes up about four-fifths of the air. In that form it can be assimilated only by legumes such as the cowpea, crimson clover, hairy vetch, soja bean, etc., through the action of bacteria in the nodules which exist upon the roots of these plants. The most commonly used organic nitrogenous substances are dried blood, tankage, fish scrap, cottonseed meal and stable manure. Sulphate of ammonia is the only ammonium salt which is used to supply nitrogen for fertilizing purposes. Calcium cyanamide is also called lime nitrogen or mineral nitrogen, and is a product of recent manufacture, for which good results are claimed but which has not yet come into general use. Nitrate of soda is the only nitrate which is used for fertilizing purposes.

But although nitrogen may be supplied in all these forms, it appears that it is taken up by most plants with the greatest readiness in the form of nitrates. All the nitrogenous substances, added to arable soil, finally form nitrates. The readiness with which nitrates are formed in any soil from any nitrogenous fertilizer, has therefore an important bearing upon the crop-producing power of that fertilizer upon that soil. The formation of nitrates in the soil is called nitrification.

CONDITIONS FOR NITRIFICATION.

The formation of nitrates in the soil is accomplished by other changes, which it is unnecessary to discuss in this paper. It was shown by Schloesing and Muntz, in 1877, that the formation of nitrates from nitrifiable substances was due to minute organisms or bacteria. In order for these bacteria to do their work it is necessary that there be (1) suitable food for the bacteria, such as potassium, calcium, sulphur, phosphorus, etc., in combined forms and organic matter, (2) some base-forming material like calcium carbonate to

neutralize the acids which are formed during the process, (3) a suitable temperature, (4) sufficient moisture, (5) sufficient oxygen, and (6) absence of substances which are poisonous to the bacteria.

It will be noted that these are the conditions which are favorable for the growth of ordinary plants. We are not surprised that these conditions are the same, since bacteria are minute plants, and the conditions favorable to the growth of minute plants would naturally be the conditions favorable to the growth of large or ordinary plants, except that light is not necessary for the growth of nitrifying bacteria, and it is necessary for ordinary plants.

METHOD OF THE EXPERIMENTS.

The object of our experiments was to ascertain the relative rate of nitrification of the different materials in the same soil and the comparative nitrifying power of different soils. On account of the difficulty in controlling the conditions in the field, our experiments were performed in the laboratory, using small quantities of soils in jars and keeping the conditions uniform and approximating those of the field. The temperature was kept at about 85° F, and water was added twice a week in sufficient quantities to keep the soil about one-third saturated. The soils were sifted so as to be uniform, the same amount of nitrogen was added to each soil in the form of different materials, and for the purposes of greater accuracy in analysis, in quantities somewhat larger than in ordinary farm practice. When calcium carbonate was added, a uniform amount was taken. At the end of three or four weeks the nitrates were leached out with water and the amounts determined. In this way it was possible to secure uniform conditions as to everything except (1) materials for supplying nitrogen, (2) food for bacteria in the different soils, (3) bacteria in the different soils, and (4) toxic substances, if any, in the different soils. In some of the experiments the bacteria in the soils were all killed and others were supplied later by the addition of weighed amounts of other soils which contained nitrifying bacteria. In this way the conditions were approximately the same except as to (1) materials for supplying nitrogen, (2) food for bacteria in the different soils, and (3) toxic substances, if any, in the soils.

NITRIFICATION OF DIFFERENT MATERIALS.

The different materials tested by us were: sulphate of ammonia, dried blood, dried fish, tankage, bone, cottonseed meal, and stable manure. Different grades of soil were used. In some soils, fish gave the most nitrates at the end of the experiment, in others sulphate of ammonia gave most, in others cottonseed meal, and in others dried blood. Bone was nitrified least rapidly of the substances used. In some cases, where stable manure was applied in excessive quantities,

there was a reduction rather than a gain in the quantity of nitrates, but in other experiments, where the amount was but a little larger than that applied in ordinary farm practice, the formation of nitrates proceeded well and there was no loss by reduction.

NITRIFICATION IN DIFFERENT SOILS.

Soils of different types and different degrees of fertility were taken and different nitrogenous materials were mixed with them. In some soils very small quantities of nitrates were formed from any of the materials, and in other soils large quantities of nitrates were formed from any of the materials, but each soil showed some material best adapted to it so far as the formation of nitrates was concerned. Some soils used by us nitrified ten times as well as others.

The causes of the difference are to be found in the difference in the form of combination of the nitrogen supplied and in the food furnished for the bacteria in the soil and in the fertilizer, but the experiments have not proceeded sufficiently far to enable us to specify the nitrogenous materials which are best suited to any class of soils; or the food necessary to be added to any particular soil for the bacteria. As a rule, the clayey soils with a good amount of humus, showed the best nitrifying power and the sandy soils with the least humus, the lowest nitrifying power.

MEANS OF INCREASING NITRATES IN THE SOIL.

From the results of the experiments performed by ourselves, which have been referred to, and from the results of the experiments by others, the following conclusions are reached:

(1) Nitrogenous materials must be added to the soil or it is impossible for nitrates to be produced. The best and cheapest way to increase the amount of nitrogen in the soil is by growing legumes like the cowpea, crimson clover, hairy vetch, soja bean, etc., which take free nitrogen from the air, by the action of the bacteria in the nodules on their roots. When legumes are not grown nitrogen must be supplied in other forms.

(2) The use of stable manure is commended, because it warms the soil, increases its water-holding power, forms humus, supplies food for the nitrifying bacteria and liberates food which has been locked up in the soil. It should not be allowed to stand exposed to the rain or to ferment in the stable any more than is unavoidable before application to the soil.

(3) Thorough tillage is commended, because it allows better circulation of the air, which furnishes oxygen, and increases the water-holding power of the soil, both of which conditions are favorable for nitrification.

(4) The addition of lime or carbonate of lime to the soil from

time to time hastens nitrification because it neutralizes the acids which are formed in the soil and which are harmful to the nitrifying bacteria.

(5) In many soils in which nitrification proceeds well it would be hastened by the addition of fertilizers. As a rule good soils with a good nitrifying power are benefitted much more by the addition of fertilizers than poorer soils, which nitrify very little.

(6) The nitrates which are formed in the soil are very soluble in water and are therefore very easily leached out by rains. When, therefore, nitrates are present in the soil or are forming, there should always be a growing plant to take them up and prevent their loss.

(7) As soils differ as to the form of combination of nitrogen which is best suited to them, and as to their need for food for nitrifying bacteria, it is desirable for each farmer to experiment with his own fields and thus to ascertain by asking them, what is the best treatment for each.